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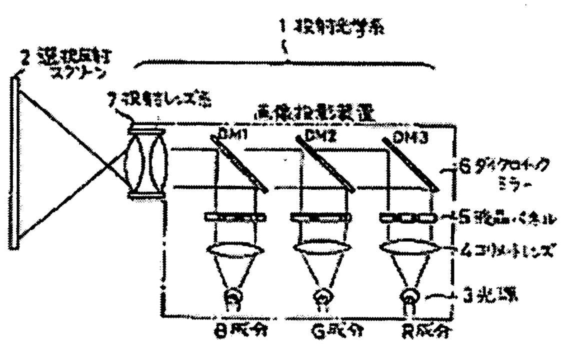
(54) [Title of Invention] Projection Type Image Display Device

(57) [Abstract]

[Purpose] The purpose is to offer a projection type image display device where the projected image contrast ratio does not decline even in a light room.

[Composition] The characteristic feature is the availability of a selective reflection screen where the reflection spectrum characteristics include a high reflectance in at least three wavelength domains; while in the other wavelength domains the reflectance is low.



[Scope of Patent Claims]

[Claim 1] In a projection type image display device equipped with an optical projection system and a screen onto which the displayed image is projected by the projection optical system, -- a projection type display device characterized in that the said screen is a selective reflection screen where the reflection spectrum characteristics include a high reflectance in at least three wavelength domains, while in the other wavelength domains, the reflectance is low.

[Claim 2] A projection type display device characterized in that the optical projection system of Claim 1 is composed of a light source, a liquid crystal panel onto which parallel light falls, once the light emitted by the said light source is converted into parallel light, dichroic mirrors that synthesize into individual colors the transmitted light that penetrates through the liquid crystal panel, and a projection lens system that projects the light synthesized into individual colors by the dichroic mirrors, onto the said selective reflection screen.

[Claim 3] A projection type image display device characterized in that in the light source of Claim 2, its spectral intensity distribution is such that a high intensity is maintained in the wavelength domain where the said selective reflection screen has a high reflectance.

[Claim 4] A projection type image display device characterized in that in the selective reflection screen of Claim 1, the reflection spectrum characteristics include a high reflectance in at least three wavelength domains, while in the other wavelength domains the reflectance is below 50%.

[Detailed Explanation of Invention]

[0001]

[Field of Application in Industry] This invention pertains to projection type image display devices.

[0002]

[Prior Art] Generally, projection type image display devices display images by projecting them on a large size screen. A universally known example of this device is a slide projector. Explanation regarding a side projector is given referring to Fig. 2.

[0003] In Fig. 2, in the slide projector, the color film 21 is illuminated from the back by white light 23 through the collimator lens 22, and the transmitted light that is based on the image information is projected onto a large size screen 25 by means of an optical projection system, for example, projection lens 24. In terms of its reflection characteristics, the large size screen 25 is preferably white, such that its reflectance does not depend on the wavelength. When used for movies, the color film can be displayed as animation as long as it successively changes time, based on the same operation principle.

[0004] However, in recent years liquid crystal projectors have become widespread where instead of the color film, liquid crystal display panels are used to project the image on the screen via the same kind of optical projection system. The liquid crystal projector shown in Fig. 3 include an optical system whose main constituent components are dichroic mirrors 32 that perform spectral dispersion of the light from the white light source 32 via collimator lenses 31 into three colors, red (R), green (G), and blue (B); an optical system whose primary constituent components are 3 liquid crystal display panels 33 that display image information of variable light and shade in accordance with these 3 colors R, G, B, and dichroic mirrors 34 (or dichroic prisms (not shown in the Figure) that synthesize the R, G, and B light transmitted through the 3 liquid crystal display panels 33; and a projection lens 35 for the projection of the synthetic light onto the screen (not shown in the Figure).

[0005]

[Problems to be Solved by the Invention] However, common problems shared by the said projection type image display devices include low brightness of the on-screen image and the need to view it in a darkened room. The requirement for viewing in a dark room leads to difficulty in easy viewing in daily living spaces and is the most important factor that interferes with the said display device becoming as widespread in households as regular television sets.

[0006] To solve this problem, brightness can be increased, and the most straightforward way to achieve this is to increase the power of the light source. However, since in a projection type image display device the displayed image is enlarged and projected onto a large screen by an optical projection system, basically it requires a light source of large luminous energy, therefore the choice is technically limited to those close to point light sources and, moreover, there is a limitation on increasing the luminous energy. Moreover, increasing the luminous energy of the light source boils down to increasing the illuminance of the displayed image, but in liquid crystal display panels etc. high illuminance is accompanied by declining characteristics of polarizing plates and array substrate circuit elements, deteriorating device performance and reduced reliability.

[0007] However, the reason that the device brightness is increased is to ensure that a clear contrast ratio of the image projected onto the screen even in light surroundings. A light room is a pace with plenty of the so-called external light. Since generally the screen cannot fully suppress the reflection of this external light, in a light room, the brightness contrast ratio of the background light and the projected picture does not come out because of the chaotic reflection of the external light, and visibility declines. For these reasons, this inventions offers a projection type image display device where the projected image contrast ratio does not decline even in a light room.

[0008]

[Means of Solving the Problems] In order to solve the said problems, the projection type image display device of this invention is one characterized in that it is equipped with at least an optical projection system and a screen onto which the displayed image is

projected by the optical projection system, and this screen is a screen is a selective screen where the reflection spectrum characteristics include a high reflectance in at least three wavelength domains, while in the other wavelength domains, the reflectance is low.

[0009] By contrast to the metal halide lamps or other white light sources with a continuous spectrum that were used as a beam light source illuminating the liquid crystal panel of Prior Art, with the light is decomposed into the three components R, G, and B by means of dichroic mirrors etc, the light sources used in this invention are those that have an emission spectrum with a narrow bandwidth wherein the wavelengths corresponding to R, G, B are the central wavelengths. Furthermore, by contrast to the reflection characteristics of the screen of Prior Art that used a white screen whose reflectance did not depend on the wavelength, in this invention, in this invention, the screen reflection characteristics are composed such that high reflectance is only in the wavelength that matches the spectrum of this light source's narrow bandwidth with a low reflectance in other bandwidths.

[0010] In this invention, the light utilization factor decline can be prevented by having the spectrum of the optical projection system match the high reflectance bandwidth domain of the selective reflection screen. On the other hand, since the screen reflectance is high only in a limited bandwidth while the other bandwidths have low reflectance, generally the external light that has the white light characteristics with a continuous spectrum is reflected by the selective reflection screen and the luminous energy that comes to the eye decreases. Therefore the contrast ration of the projected picture brightness to the external light reflection by the selective reflection screen significantly increases. The reason that the reflectance of the other wavelength bands was kept below 50% is that due to this the effect of the external light drops by half while the contrast ratio doubles.

[0011]

[Embodiments] Below, we explain the embodiments of this invention based on Figures. In Fig. 1, the projection image display device consists of the optical projection system 1 and the screen onto which the optical projection system projects the displayed image, that is, selective reflection screen 2 where the reflection spectrum characteristics include high reflectance in at least 3 wavelength domains, while in the other wavelength domains, reflectance is low.

[0012] This optical projection system 1 consists of the light source 3, the collimator lens 4 that transforms the light from this light source into parallel light, the liquid crystal panel 5 onto which this parallel light is incident, the dichroic mirrors 6 that synthesize the transmitted light that passes through the liquid crystal panel 5 into individual colors, and the projection lens 7 that projects the light in individual colors synthesized by the dichroic mirrors 6 onto the selective reflection screen 6.

[0013] Next, we will give a detailed account of the individual components of the optical projection system 1. The light source 3 is composed of individual light sources that have light emission intensity peaks at wavelengths λR, λG, and λB to match the red (R), green (G), and blue (B) components and whose spectrum bandwidths are sufficiently narrow.

The distribution of the intensity in these light spectra is depicted in Fig. 4. Examples of such light source 3 include mercury lamps, metal halide lamps, etc. The mercury and halogenated metal compounds that are enclosed and sealed can be obtained by selecting the materials and vapor pressure in accordance with the requisite spectrum. In light sources whose light emission spectrum bandwidths are broad or that emit multiple light emission spectra, the desired characteristics can be also obtained by fashioning a reflection film on the external bulb surface that would allow only the desired spectrum to pass while reflecting the undesirable spectrum light towards the light source. Further, also a luminescent tube is possible where a luminophore that has the desired spectrum is applied to the internal surface of the bulb. Since the desired spectra of these light sources are independent, the metal materials, vapor pressure, luminophores, etc. are selected independently, and there is a degree of freedom in the design of the light sources, therefore excellent light sources with high efficiency characteristics can be provided. If the peaks of light emission intensity of light sources 3 are selected individually close to λR=630 nm, λG = 530 nm, and λB = 450 nm, this is desirable since color reproduction would be true even if the R, G, and B component signals of the video signal are used without component modification.

[0014] The light emitted from this light source 3 is made parallel by the collimator lens 4, whereupon it falls in individual color component signals on the transmittance-modulated liquid crystal panel 5.The light transmitted through the liquid crystal panel 5 is synthesized into individual colors by dichroic mirrors 6 and then projected onto the selective reflection screen by the projection lens system 7. The composition after the liquid crystal panel 5 can be the same as the liquid crystal projector composition of Prior Art shown in Fig. 3. However, the spectrum reflection characteristics of the dichroic mirrors 6 are certainly superior to those of Prior Art., and the dispersion spectrum intensity from the light source is discrete as indicated in Fig. 4, therefore it is possible to consider individual dichroic mirrors 6 as follows- DM1 as Fig. 6, DM2 as Fig. 7, and dM3 as full wavelength reflection mirror. This facilitates the design of the dichroic mirrors 6 and makes the set composition cheaper.

[0015] On the other hand, the reflection spectrum characteristics of the selective reflection screen 2 are shown in Fig. 5, and high reflectance is shown in the wavelength domain that covers the light emission spectra of the light sources of individual color components, with low reflectance in the wavelength domains between individual spectrum intensity peaks of low spectrum intensities. There are numerous specific methods of constituting the selective reflection screen 2 that has such reflection spectrum characteristics, and we show an example thereof below. Figs. 8 and 9 show an example of constitution method based on interference filters. Fig. 8 shows the constitution of a cross-section of the screen. Multiple layers of interference filters 62, 63, 64 are configured uniformly on the surface of the low reflection black substrate, that is, low reflection substrate 61. As shown in Fig. 9, individual layers of interference filters 62, 63 and 64 reflect the incident light in individual wavelength domains where high reflectance is required, while the light in from other wavelength domains reaches the low reflection substrate 61 without being reflected by any of the interference filters 62, 63 or 64, and is absorbed by the substrate 61. Fig. 10 is another example where the screen is constituted

by multiple layers of absorption type filters. The light from specific bandwidth domains is absorbed by the surface of the reflection plate 73 where the reflection film 72 is formed on the substrate 71, and absorption type filters AF1, AF2, AF3, and AF$ are formed that absorb the light from other bandwidths. The transmission spectrum characteristics of individual layers are designed as own in Fig. 11. The light from wavelength domains of low transmittance is absorbed by the absorption filters AF1, AF2, AF3, and AF4, and the reflectance on the surface of the absorption filters AF1, AF2, AF3, and AF4 is kept sufficiently low. Therefore the light from wavelength domains that passes all the absorption filters AF1, AF2, AF3, and AF4 reaches the reflection film 72 on the surface of the substrate 71, and, upon passing again through all the absorption filters AF1, AF2, AF3, and AF4,.is radiates from the surface of the selective reflection screen. The layers of absorption filters AF1, AF2, AF3, and AF4 that have such transmission spectrum characteristics can be easily realized by forming films from polymers with added pigments that possess specific spectrum absorption characteristics. Alternatively all the absorption filters AF1, AF2, AF3, and AF4 can be configured into a single layer by mixing these pigments. Moreover, since these absorption type filters exhibit little dependence on the angle of the incident light, the suitable reflection film can be a scattered reflection plate or have a lenticular lens provided between reflective films to ensure screen gain. Furthermore, a flexible screen can be readily made from the components.

[0016]

[Effect of Invention] By virtue of the said composition, due to the use of a selective reflection screen in the projection type image display device of this invention, the external light reflection by the screen occurs only within a specific narrow wavelength domain, while in other wavelength domains the light is absorbed by one of the screen layers without reflection. Since usually external light in a room is either incident sunlight or the chaotically reflected light from the lighting fixtures in the room, even though its spectrum characteristics have variable strength, it is a continuous spectrum. Therefore the reflected energy of the external light from the selective reflection screen is reduced by the part of the light energy that corresponds to the domain absorbed by the screen. On the other hand, since the spectrum of the light projected from the projector matches the reflection spectrum characteristics of the selective reflection screen, the reflected energy is not attenuated. As a result, the light reflected from the reflection screen is only reduced by the reflected energy of the external light; therefore the contrast of an image with this reduction is increased.

[Brief Explanation of Figures]

[Fig. 1] is a sketch of the composition showing an embodiment of the projection type image display device of this invention.

[Fig. 2] is a sketch of the composition showing an example of the projection type image display device of Prior Art.

[Fig. 3] is a sketch of the composition showing an example of the liquid crystal projection type image display device of Prior Art.

[Fig. 4] is a diagram of the spectrum intensity distribution required in this invention.

[Fig. 5] is a diagram of the spectrum reflection characteristics of the selective reflection screen of this invention.

[Fig. 6] is a diagram showing the spectrum reflection characteristics and spectrum transmittance characteristics of the dichroic mirror DM 1 shown in Fig. 1.

[Fig. 7] is a diagram showing the spectrum reflection characteristics and spectrum transmittance characteristics of the dichroic mirror DM 2 shown in Fig. 1.

[Fig. 8] is a sketch of the cross-section composition showing an example of the selective reflection screen that is included in this invention.

[Fig. 9] is a diagram that shows spectrum reflection characteristics of the selective reflection screen shown in Fig. 8.

[Fig. 10] is a sketch of the cross-section composition showing another example of the selective reflection screen that is included in this invention.

[Fig. 11] is a diagram that shows spectrum transmittance characteristics of the absorption filter layer of the selective reflection screen shown in Fig. 10.

[Explanation of symbols]

(1) ...optical projection system

(2)...selective reflection screen

(3)...light source

(4)...collimator lens

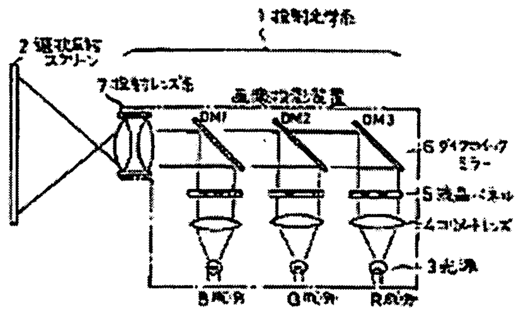
(5)... liquid crystal panel

(6)... dichroic mirror

(7)...projection lens system.

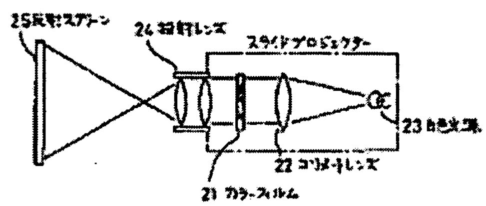
Key to Figures:

Fig. 1



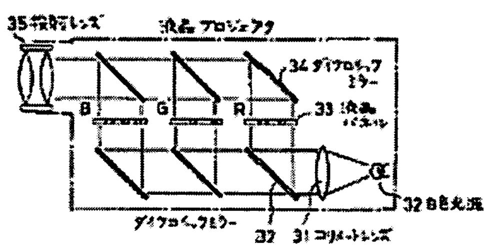
A- image projecting device; B- B component; C- G component; D – R component

Fig. 2



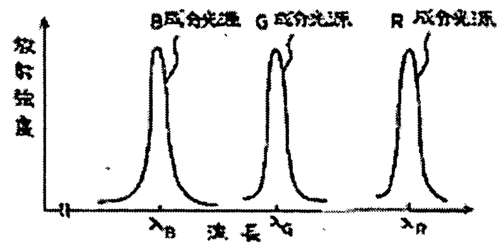
21 – color film; 22 – collimator lens; 23 – white light source; 24 – projection lens; 25 – reflection screen; A – slide projector

Fig. 3



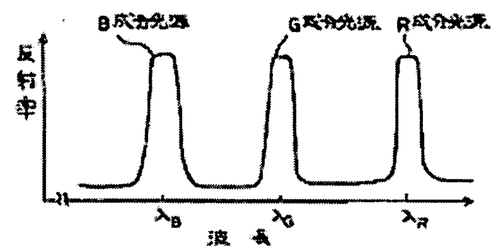
A – liquid crystal panel; B – dichroic mirror; 31 – collimator lens; 32 – white light source; 33 – liquid crystal panel; 34 – dichroic mirror; 35 – projection lens.

Fig. 4



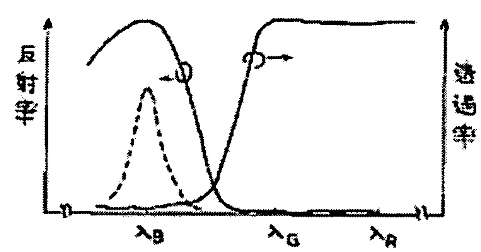
A – reflection intensity; B – wavelength; C – B component light source, D – G component light source; E – R component light source.

Fig. 5



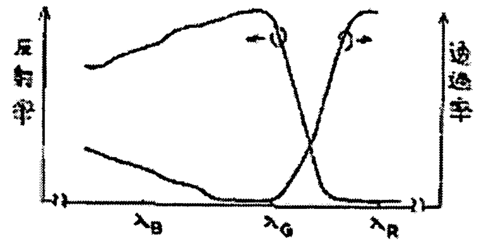
A – reflectance; B – wavelength; C – B component light source, D – G component light source; E – R component light source.

Fig. 6



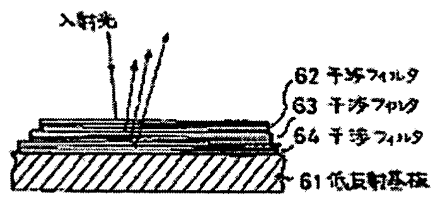
A – reflectance; B – transmittance

Fig. 7



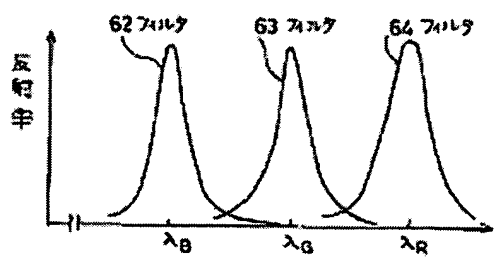
A – reflectance; B – transmittance

Fig. 8



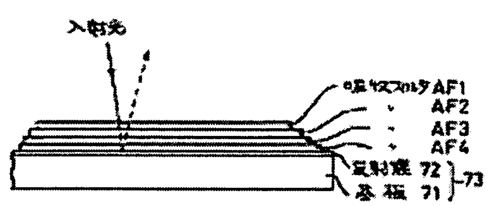
A – incident light; 61 – low reflection substrate; 62, 63, and 64 – interference filters.

Fig. 9



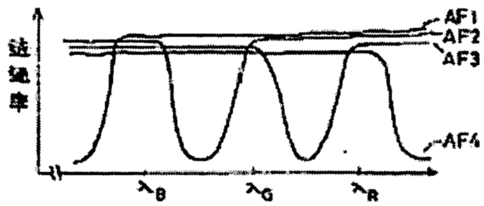
A – reflectance; 62, 63, and 64 – filters

Fig. 10



A – incident light; AF1, AF2, AF3, and AF4 – absorption filters; 71 – substrate; 72 – reflection film.

Fig. 11



A – transmittance

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